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ENGINEERING WORKSHOP-METALS, MARKING OUT AND MEASUREMENTS

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Page

1. INTRODUCTION

1.1 This paper is one of a series on the subject Engineering Workshop Practices, and provides basic information on materials and general workshop procedures. Other papers in the Engineering Workshop series - 'Hand and Power Tools', and 'Forming, Fastening and Heat Treatment', - include information on the use of tools and workshop techniques.

1.2 Although these papers are included for use in training Telecommunications Tradesmen, the descriptions of some practices and procedures extend beyond those normally required. These are to assist the Tradesmen in performing more unusual tasks that are normally encountered, and to enable him to have a broad general knowledge of engineering processes.

2.1 TOOLS AND MATERIAL STORAGE. In the interests of general safety and efficiency the well planned workshop contains suitable storage facilities for tools and materials. Considerable time is saved by avoiding needless searching for tools and materials. Tools in frequent use, may be stored in suitably compartmented drawers at the work position. The drawers should be fitted out with brackets to hold these items. Files, squares, steel rulers, and similar items, which can cause damage to each other should not be stored in the same compartment, or contact each other on the bench.

Tools not provided on an individual basis are best kept in a common tool cupboard. Shadowboards are recommended so that tools may be given specific storage space, and be easily located and replaced after use. Materials not required for immediate use are best kept in a store, or an area set aside for this purpose, and fitted with storage racks. Material must not be left in passage ways or other areas where it could become a hazard to personnel. This applies particularly to round stock which may roll when stepped on, possibly causing a fall.

2.2 SUITABLE CLOTHING. Fig. 1. illustrates good and bad points concerning dress. The most suitable apparel is a one piece overall or boiler suit maintained in good condition. Overall buttons must be kept fastened. Ties and scarves should not be worn, and torn material should be avoided as loose material can become caught in moving machinery.

When working near moving machinery, sleeves should be either tightly rolled or buttoned at the wrists.

Safety boots or shoes should be worn as protection against falling objects, etc..

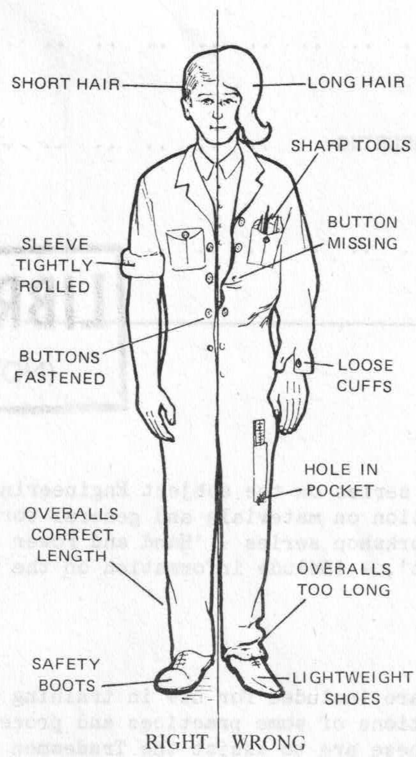


FIG. 1. SAFE AND UNSAFE DRESS.

Goggles (safety glasses) must be worn where there is any possibility of flying particles being encountered. This applies particularly when working at, or near, a grinder, drilling machine, lathe etc., or where chisels are being used.

Wrist watches and rings should not be worn in the workshop as they have been known to contribute to injury.

2.3 WORK AREA CLEANLINESS AND TIDINESS.

The work bench and adjacent areas should be kept as clean as practicable. Only the tools required for the work in hand should be on the bench, (Fig. 2).

Workshop floors should be kept clear of material and equipment, and any spilt oil or grease must be removed immediately.

Do not use old cotton waste for cleaning as it may contain metal chips.

Machines should be cleaned of swarf with a sash brush.

Cleaning must be carried out only when the machines are stationary.

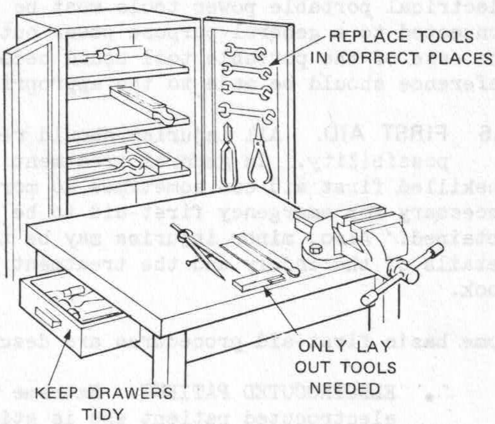


FIG. 2.

2.4 SAFETY.

Workshop accidents are avoided by the correct use of tools and equipment and by a thorough knowledge of the operations involved in any task. When the correct methods of carrying out a particular task are not fully understood, the operation should not be attempted until advice has been obtained.

Hand tools should be checked for condition before being used. Avoid using hammers with loose fitting handles or chipped faces. Chisels with burred heads are dangerous when used, as chips may fly off and cause injury. File handles must be tightly fitted. Hardened tools, such as files, must not be struck as chips may fly off. Spanners should be of the correct size, and should be used in a manner which will avoid injury should they slip.

Machine tools must be treated with extreme care. Avoid the temptation of starting machines with which you are not familiar. Never use cotton waste or similar material near rotating shafts or other moving parts. Never attempt to remove or replace a belt on a moving pulley, by hand. Particular care must be taken to avoid contact with moving belts.

If for any reason an unattended machine must be left running a suitable notice should be placed on it. (Fig. 3).

When about to use a machine for the first time, ensure that you know how to stop it if the need suddenly arises.

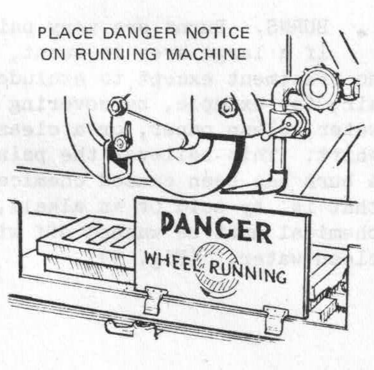


FIG. 3.

Compressed air is very powerful, and great care is required where it is being used. Wear safety goggles and gloves when using compressed air for cleaning purposes as it can drive particles of swarf and dust through the skin. Compressed air must never be directed towards the skin or clothing as it can cause blistering.

Electrical equipment, such as portable power tools, should be inspected regularly for damaged or faulty flexible cables. Any defective equipment must be repaired by authorised personnel, before use. With the exception of 'double insulated' types, electrical portable power tools must be effectively earthed. They should only be connected to a general purpose power outlet. If the earthing system is not intact, the case of the portable tool could become live, with possible fatal results. Reference should be made to the appropriate A.P.O. Engineering Instructions.

2.5 FIRST AID. All injuries should receive treatment as infection is always a possibility. In general treatment should be given by qualified persons as unskilled first aid can sometimes do more harm than good. However, it may be necessary for emergency first-aid to be administered before skilled treatment can be obtained. Also, minor injuries may be treated locally, although it is important that details of the injury and the treatment given, be recorded in the appropriate record book.

Some basic first-aid procedures are described in the following paragraphs.

- ELECTROCUTED PATIENT. Extreme care is needed when dealing with an electrocuted patient who is still in contact with the power. When the power cannot be turned off quickly, the patient must be dislodged from the point of contact by means of some insulating material such as dry wood. Direct contact with the patient must be avoided until this has been done. When the patient has been removed from the power, immediately check for normal breathing and heart action.

- SEVERE BLEEDING MUST BE CONTROLLED. Squeeze together the sides of the wound. Apply pressure as long as it is necessary to stop the bleeding, (Fig. 4). When the bleeding has stopped, put a dressing over the wound, and cover it with a pad of soft material.

  For abdominal stab wounds, such as caused by falling on a sharp tool, keep the patient bending over the wound to stop internal bleeding.

- BURNS. Burns are very painful. If a large area is burnt, give no treatment except to exclude the air, for example, by covering with water, clean paper, or a clean shirt. This relieves the pain. If a burn has been caused chemically, that is, by acid or an alkali, the chemical must be washed off with clean water. (Fig. 5).

STOP BLEEDING WITH PRESSURE AT THE WOUND

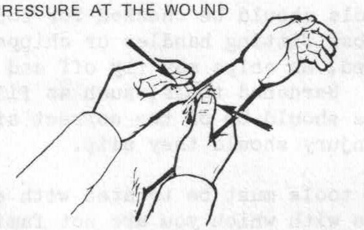
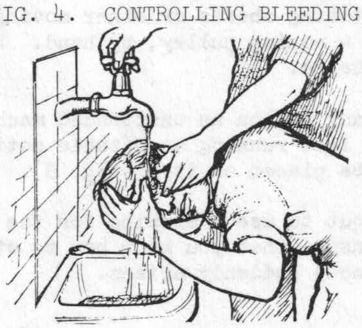


FIG. 4. CONTROLLING BLEEDING.



WASH OFF CHEMICALS WITH WATER

FIG. 5. TREATING CHEMICAL BURNS.

- SHOCK. This is a state of collapse which, if not treated, may cause death. The prime causes of shock are loss of serum and body fluids. These may result from injuries, burns, diarrhoea, vomiting, pain and infection. A person may also suffer shock as a result of severe injuries, a bad fright, a heart attack or excessive exposure to heat.

Symptoms of shock are giddiness, faintness, thirst and nausea. Outward signs include rapid shallow breathing, initially slow pulse which becomes more rapid and feeble, cold, clammy pale skin, vomiting, reduced mental activity, then unconsciousness.

The following steps should be carried out while medical assistance is being sought.

Check that the patient has adequate fresh air.
Control bleeding.
Maximise blood supply to the brain by placing the patient flat and raising the legs (This assumes no head injuries).
Keep patient sufficiently warm to prevent shivering.
Ensure minimum sweating to prevent body fluid loss.
Ease pain where possible.
Reassure the patient.

Fluids may be given in small quantities provided that the patient is conscious, is able to swallow, is not nauseous, and there are no abdominal injuries.

WARNING - DO NOT GIVE ALCOHOL.

- KISS OF LIFE. If breathing stops or bleeding is severe, prompt action can save life. Treatment should be given by a qualified person, but where no such person is immediately available, it is the responsibility of the persons on the scene to save life. If breathing stops the 'kiss of life' should be applied and medical assistance called at the same time. The kiss of life is illustrated in Fig. 6 and described as follows:

(a) Remove any obstruction from the patient's mouth. Support the nape of the neck, and press the top of the head backwards.

(b) Press the angle of the jaw forward from behind, then;

(c) Open your mouth wide and take a deep breath. Pinch the patient's nostrils together. Seal your lips round his mouth. Blow gently into his lungs until they are filled. Remove your mouth. Watch the patient's chest movements. Repeat until the patient breathes by himself.

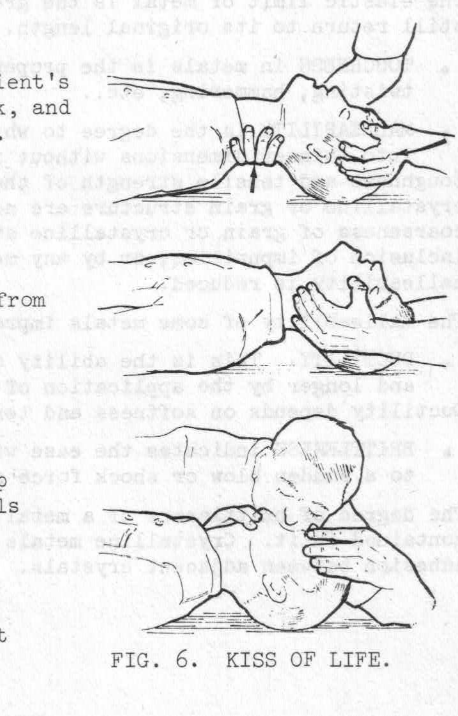


FIG. 6. KISS OF LIFE.

3. METALS AND ALLOYS

3.1 **CHARACTERISTICS OF METALS.** Nature has provided more than 50 different kinds of metals, but for many reasons such as scarcity, rapid oxidation, etc., only about 12 can be used for general purposes.

Different metals possess different qualities, and it is these qualities which make one metal suitable for a particular purpose and useless for another purpose. For example, elasticity is essential in the metal used for making a spring, also lustre is useful to prevent oxidation, but whether the metal can be welded or not may not matter. The chief characteristic needed in a metal from which a bell is made is sonorousness, but the metal's power of conductivity does not count. On the other hand, conductivity is the most important feature of a metal to be used for electrical purposes, and its sonorousness need not be regarded.

It is important, therefore, that the different qualities possessed by metal should be known and understood.

3.2 The following terms are commonly used to describe metals and alloys.

- STRENGTH. The strength of metals is expressed in several ways. 'Tensile strength' is a measure of the resistance offered by the metal to being pulled apart. It is measured in terms of the force per unit cross-sectional area required to cause rupture.

  'Compressive strength'. This is a measure of the force required to cause breakage or bending when subjected to crushing.

  'Fatigue strength' is a measure of the resistance offered by a metal to failure under conditions of vibration or repeated alternating between compression and tension type loading.

- ELASTICITY is the ability of a metal body to recover its original bulk or shape after having been subjected to a stretching, bending or compressive force.

  The elastic limit of metal is the greatest amount that it can be stretched and still return to its original length.

- TOUGHNESS in metals is the property of resistance to fracture by bending, twisting, hammering, etc..

- MALLEABILITY is the degree to which a metal may be hammered or rolled out into thinner dimensions without fracture. This property depends on the toughness and tensile strength of the metal. Metals having a coarse crystalline or grain structure are not malleable. This means that when the coarseness of grain or crystalline structure of a metal is increased by the inclusion of impurities, or by any mechanical or physical action, the malleability is reduced.

  The malleability of some metals improves when the temperature is increased.

- DUCTILITY. This is the ability of metal to be drawn out or made thinner and longer by the application of a tensile stress or drawing out force. Ductility depends on softness and tensile strength.

- BRITTLENESS indicates the ease with which a metal breaks when subjected to a sudden blow or shock force such as when hammered.

  The degree of brittleness of a metal depends on the amount of impurities contained in it. Crystalline metals are usually brittle because of the poor adhesion between adjacent crystals.

- HARDNESS. This is the resistance offered by a metal to cutting or grinding.

Metals containing impurities are usually harder than when in the pure state. The degree of hardness in metals decreases as temperature is increased.

- FUSIBILITY is the property of a metal to become liquid when sufficiently heated. This feature is a most useful one as it allows various metals to be alloyed, castings to be poured, and metal parts to be joined by soldering, brazing or welding. Each metal has particular melting temperature.

When alloyed with other metals, the melting temperature is governed by the proportions of each metal.

- CONDUCTIVITY. This is a measure of the rate at which metals and alloys transmit heat and electricity. Hence the terms 'Thermal Conductivity' and 'Electrical Conductivity'. The electrical conductivity of a metal is practically equal to its thermal or heat conductivity, and in both these instances, the presence of even a very small amount of impurity in the metal will diminish its conductivity. The electrical conductivity of a metal is much decreased by a rise in temperature. Silver has the highest thermal conductivity and electrical conductivity of all metals.

- CORROSION RESISTANCE is the ability of a metal to withstand the 'eating away' effects of oxygen, acids, etc..

Most metals have a tendency to combine with oxygen and this effect is more noticeable in a warm damp atmosphere.

Various means, such as polishing and electroplating, are employed to reduce the rate at which corrosion takes place.

The well-known metals will dissolve in acids, and this is made use of particularly in cleaning metals before polishing and lacquering. Iron, zinc, silver, lead and copper will dissolve in nitric acid, while, with the exception of platinum, silver, lead, gold and copper, all m tals will dissolve in hydrochloric acid.

3.3 METALS. Selection of materials suitable for a given task, requires a knowledge of the principal characteristics required, and any special difficulties likely to be encountered when machining.

Some characteristics of the more popular metals in general use, together with typical uses, are described in the following paragraphs.

- WROUGHT IRON. This metal is considered for all practical purposes to be pure iron, as it does not contain more than 0.25% carbon. It is light grey in colour, fibrous, tough, and ductile at a high temperature; it is very easily forged and welded but cannot be cast. Owing to the comparative cheapness and general utility of modern mild steel, the production of wrought iron has greatly decreased of recent years. It is now used mainly for chain making, because of its unique welding properties, and also for the production of cast steel.

- CAST IRON. There are several grades of cast iron, varying in carbon content between 2% and 5%.

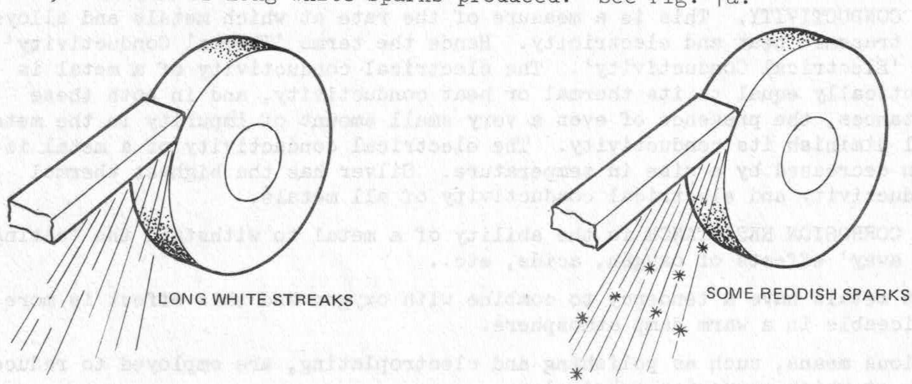
Generally of an open texture it is crystalline, brittle and will not bend. It withstands compressive forces, is self lubricating, easily cast, and hard wearing.

The surface of castings is usually hardened by chilling in a sand mould. This means that preliminary grinding is often necessary to remove the hard skin prior to machining

Cast iron is typically used for machine beds, engine blocks, marking-off tables, heavy duty industrial wheels, gear wheels, etc..

- STEEL. The word 'steel' embraces both 'mild' and 'cast' steel, and the usual method of determining the difference between the two classes is as follows - mild steel (which contains less than 0.5% carbon) when heated to redness and quenched in water does not appreciably harden, whereas cast steel (0.5-1.5%) carbon does harden when so treated.

Mild steel is greyish-white in colour, has a medium fine grain, can be forged and welded, is strong in compression and tension and is used for structural steel work, shipbuilding, rails, shafting, bolts, nuts, rivets, motor car bodies, etc.. It can also be recognised by the spark test, that is, when ground on a grinding wheel, a stream of long white sparks produced. See Fig. 7a.



(a) Mild Steel. (b) Medium Carbon Steel.

FIG. 7. RECOGNITION OF STEELS BY GRINDING.

Medium carbon steel is harder than mild steel. As the carbon content of the steel is made greater, the sparks produced by grinding occasionally burst, so that medium carbon steel produces long white streaks mixed with reddish sparks. (Fig. 7b). Medium carbon steels are used for such items as springs, hammers and shear blades.

Cast steel is greyish-white in colour, malleable, ductile, tough, but rather brittle; it is very hard to weld, and when fractured shows a very fine crystalline grain. It is used chiefly for making cutting tools of all descriptions, and machine parts that are required to withstand extreme wear. Cast steel is also referred to as 'carbon' or 'tool' steel.

Cutting tools for engineering and woodworking machinery are made of 'high speed' steel. This is a special alloy carbon steel, varying somewhat in its constituents but generally containing one or more of such elements as chromium, tungsten, vanadium, etc.. High speed steel will stand up to much higher speeds and feeds than ordinary carbon steel and, generally speaking, no tempering is required, the steel being hardened by a quick cooling off in an air blast, or in whale or cottonseed oil.

- TIN. Pure tin is white, tinged with yellow. It is soft, malleable, ductile, takes a high polish, cannot be forged or welded, does not oxidise and is used as tinfoil for wrapping purposes, for coating purposes (for example, in the manufacture of tinplate), and for mixing with other metals to form such alloys as soft-solder and gunmetal. Melting point is 232°C.

- ZINC. This metal is bluish-white in colour, cannot be forged or welded, does not readily oxidise, is soft and malleable but very brittle when worked and, therefore, requires constant annealing by dipping in boiling water and allowing to cool slowly. It is used in sheet form for such things as linings for packing cases and dry cells, for coating sheet steel to form 'galvanised iron', and also forms part of numerous alloys, such as, brass, brazing spelter and nickel silver. Melting point is 415°C.

- COPPER. Copper is reddish-brown in colour, very malleable and ductile, can be highly polished, forged hot or cold but cannot be welded in the forge. It is an excellent conductor of heat and electricity, resists corrosive action and is used for electrical wire and accessories, cooking utensils, nails, rivets, tubing, etc., and also for alloying purposes in the manufacture of brass and bronze. It does not make good castings, and sheet copper requires constant annealing by heating to redness and quenching in water when being worked into shape. Melting point is 1080°C.

- LEAD. This metal is bluish-grey in colour, very soft and malleable, ductile, heavy, may be cast but not forged or welded in the forge, and is practically indestructible. It is used for sinks and dishes in chemical laboratories, waste pipes, ballast, shot, dampcourse, the manufacture of paint, roofing, etc., and forms part of such alloys as soft-solder, pewter and white-metal. Melting point is 327°C.

- ALUMINIUM. Aluminium is greyish-white in colour, very light in weight, takes a high polish, does not corrode except with strong alkalies or concentrated acids, is very malleable, may be cast, rolled or pressed but not forged or welded in the forge, and is a good conductor of heat and electricity. Pure aluminium is too soft and weak for most purposes but its alloys (for example, duralumin) are very useful, and these are largely used in the manufacture of aircraft and motor-car parts. Aluminium is also used to a limited extent for power cables, busbars and telephone cables. As this metal does not satisfactorily soft-solder, it is usually welded, rivetted, crimped or clamped. Melting point is 655°C.

- SILVER. This metal is lustrous white in colour, soft, extremely malleable, takes a high polish and does not oxidise. Used (generally alloyed with copper) in the manufacture of electrical contacts and also for alloying purposes. Melting point is 960°C.

- GOLD. Gold is bright yellow in colour, extremely malleable, may be highly polished, not subject to corrosion and is used in the manufacture of semiconductors and electrical contacts. Pure gold is said to be '24 carat'. Melting point is 1060°C.

- PLATINUM. This metal is white in colour, extremely malleable, rare, does not readily oxidise, is very heavy and is practically non-fusible. It is used in the manufacture of electrical and chemical apparatus in cases where resistance to the oxidising effect of high temperatures is essential. Melting point is 1755°C.

- TUNGSTEN. (Wolfram). Added in small amounts to steel, tungsten hardens and toughens the metal. Tungsten is nowadays universally employed for making the filaments of electric lamps, as it is almost infusible and is thus able to withstand the prolonged heating to whiteness. In many of its properties, tungsten is allied to molybdenum, and chromium alloys of tungsten with aluminium, antimony, bismuth, cobalt, copper lead and nickel, have been obtained. Melting point is 3370°C.

- NICKEL. When pure, it is a highly lustrous white metal. It is hard, easily polished, ductile and malleable. Nickel, like cobalt, is slightly magnetic. Until recent times it was used largely as a plating metal since plated nickel gave a fine finish to base metals. Added in small amounts to steel, the metal forms the various nickel-steels which are exceedingly hard and which have been employed for armour-plating purposes, as well as for other uses. In these, the proportion of nickel may be as high as 20%.

  Nickel enters into a large number of alloys of widely varying characteristics and it is used mostly as an alloying metal. A certain amount of pure nickel is employed for the making of instruments, etc.. Melting point is 1435°C.

3.4 ALLOYS. An alloy is a mixture and/or combination of two or more metals forming an apparently homogeneous mass. Alloys can be produced by the simple admixture of the molten metals by the smelting of mixed ores, by electrolytic methods, or by the compression of mixed metallic powders. Alloys containing mercury are called amalgams.

The general effects of alloying metals together is to lower the melting point and conductivity, increase the hardness, and sometimes increase the strength of the metal. Colour changes are often brought about by alloying, and in many other ways, the properties of the alloying metals are significantly modified in the resultant alloys.

- ALLOY STEELS. There are varieties of steel containing considerable percentages of other metals such as tungsten, chromium, nickel, manganese, etc., which have been added for the sake of increasing the hardness, strength or corrosion resistance of the metal, or for some other special purpose. Such steels are also known as 'Special Steels'. Alnico is one such steel; aluminium-nickel-cobalt steel it is used for making permanent magnets and magnet cores. It offers a maximum amount of magnetic energy per unit mass of metal and, in this respect, constitutes a great advance on the old magnet steels. Composition - steel, 50%; aluminium, 20%; nickel, 20%; cobalt, 10%.

- BRASS. This alloy is light yellow in colour, consisting of about 70% copper and 30% zinc. The proportions vary, however, according to the ultimate use of the alloy, a mixture as low as 60/40 often being used. It is very malleable and ductile, takes a high polish, will not easily corrode, is a good conductor of heat and electricity and is utilised extensively in sheet, tube and bar form and makes excellent castings. It is used in the manufacture of electrical apparatus, scientific instruments, screws, locks, parts of machinery exposed to water and ornamental fittings, etc.. Sheet brass requires constant annealing in the same manner as sheet copper when being worked into shape. Melting point is 900°C.

- BRONZE. This is the name given to a large class of copper-zinc-tin alloys. Approximate limiting proportions of these constituents are - copper, 70-90% zinc, 1-25% and tin 1-18%.

  Bronzes are used for making castings, bearings, etc..

- NICKEL-SILVER. Also called 'German Silver'. Contains copper (56-60%), zinc (20%), nickel (20-25%) and sometimes a small amount of cobalt, lead and iron. Inferior qualities contain not more than 7% of nickel. Owing to its white colour, lustre, toughness, tenacity, malleability, ductility and chemical resistance, any good quality nickel-silver or German silver is a very useful metal for ornamental work. It has a high electrical resistance, and is also used for the manufacture of electrical resistance wire in addition to many other important uses.

  The nickel or German silvers have a fairly high tensile strength of from 386 to 617 megapascals (newtons per square millimetre).

4. DRAWINGS

4.1 ENGINEERING DRAWINGS. The construction or modification of any article depends on clear and accurate drawings which show the shape of the article, all relevant measurements or dimensions and, where necessary, the procedure to be followed.

4.2 The three basic types of drawings in general use are known as perspective, isometric and orthographic projection.

- PERSPECTIVE DRAWING. The object is drawn as it appears to the eye. It is used to show the finished appearance of the article. The outstanding feature of this type of drawing is that parallel lines or edges of the subject are drawn converging as they recede from the view-point. This is shown in Fig. 8.

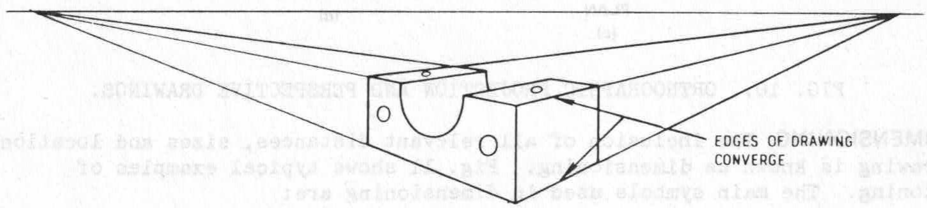


FIG. 8. PERSPECTIVE DRAWING.

- ISOMETRIC DRAWING. This drawing combines some of the pictorial effects of the perspective with the facility of being able to measure the principal lines directly. All lines which are parallel on the object, are drawn parallel and all lines may be drawn to scale. Fig. 9, shows an isometric drawing of an article.

  The isometric drawing is often inadequate where detailed information is required. It is used mainly as an aid to interpretation of more detailed drawings.

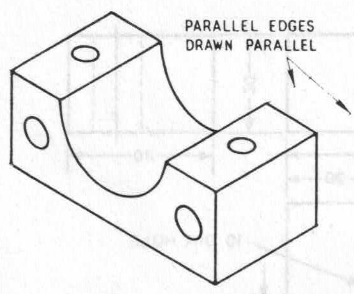


FIG. 9. ISOMETRIC DRAWING.

- ORTHOGRAPHIC PROJECTION. This type of drawing is very frequently used where detailed information is required. The main feature of the orthographic projection type drawing is that at least two views are shown, each of which shows true shape.

Figs. 10a, b and c show an object drawn in orthographic projection and for comparison, the same object is shown in perspective in Fig. 10d.

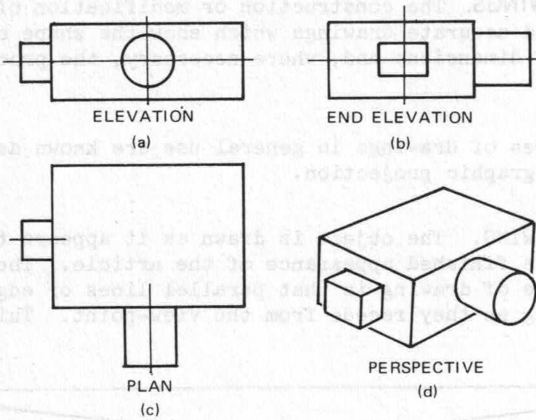


FIG. 10. ORTHOGRAPHIC PROJECTION AND PERSPECTIVE DRAWINGS.

4.3 **DIMENSIONING.** The inclusion of all relevant distances, sizes and location on a drawing is known as dimensioning. Fig. 11 shows typical examples of dimensioning. The main symbols used in dimensioning are:

- DIMENSION LINES. Fine lines which indicate the extent of each dimension.
- EXTENSION LINES. Fine lines extending from features of a drawing, to indicate the feature to which the dimension applies.
- LEADERS. Fine lines leading from a note or figure to the feature to which the figure or note applies.
- ARROW HEADS. Dimension lines and leaders are terminated with arrow heads.

The value of a dimension is usually shown by figures or notes placed in a gap in a dimension line or at the end of a leader. (Fig. 11).

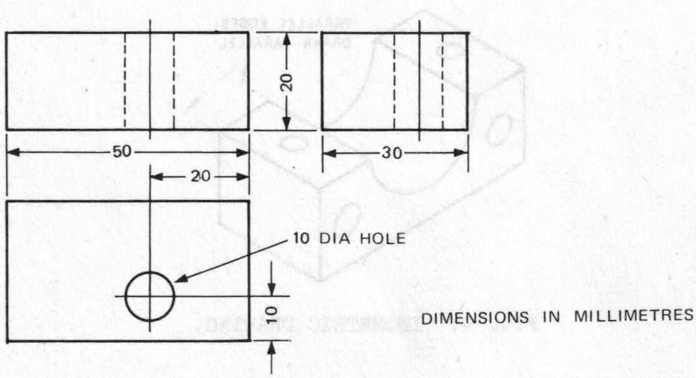


FIG. 11. DIMENSIONING.

Dimensioning of small sizes may be shown as in Fig. 12.

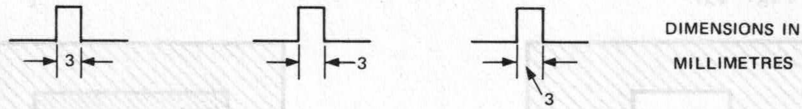


FIG. 12. SMALL SIZE DIMENSIONING.

Some methods of dimensioning curved surfaces by radii are shown in Fig. 13. Fig. 13a shows the method used where the location of the centres is not required. Fig. 13b shows the method used where the location of the radii centre is required. Figs. 13c and 13d are methods used to show the dimensions of small radii.

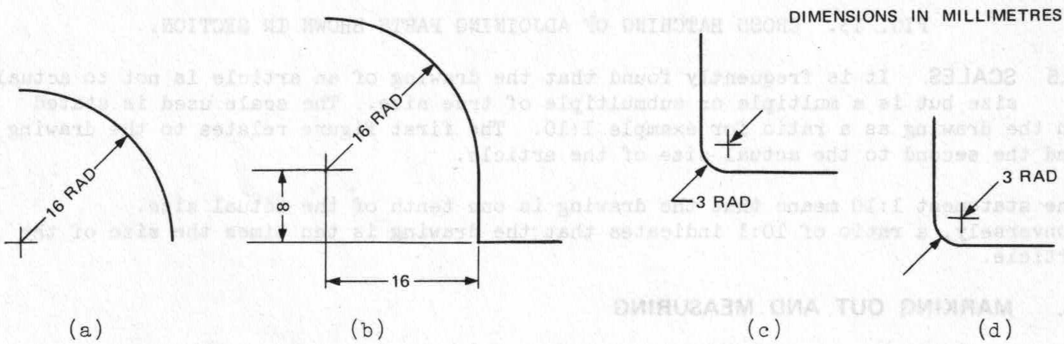


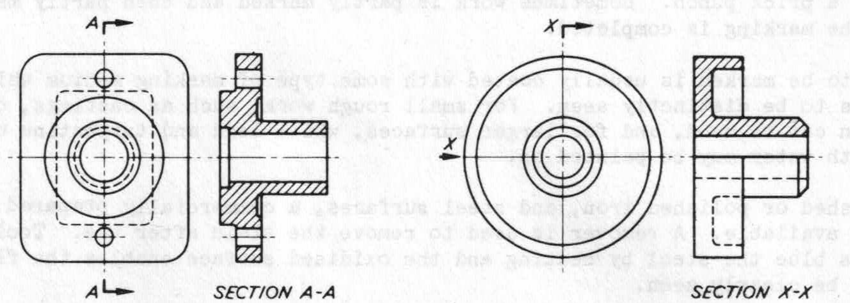
FIG. 13. DIMENSIONING RADII.

4.4 SECTIONING. A sectional view of an article is one in which the article is shown as it would appear if cut open along a particular plane. The plane is specified on some other view of the article.

The following conventions are adopted where applicable in Section drawings:

- FULL SECTION. When the cutting plane extends entirely through the object, as in Fig. 14a, the resultant view is known as a 'Full Section'. In such cases the cutting plane is usually made to coincide with the main axis or centre line.

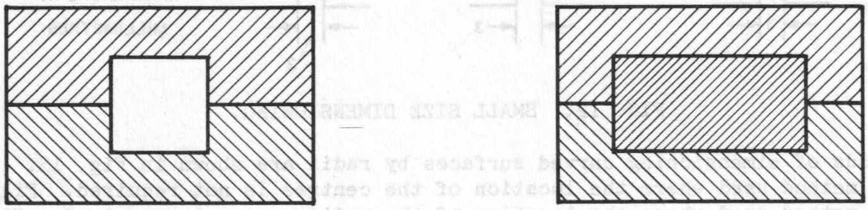
- HALF SECTION. When an object is symmetrical a half section may be drawn as in Fig. 14b. The object is cut by two planes at right angles to each other and this has the effect of removing a quarter segment.



(a) Full Section. (b) Half Section.

FIG. 14. SECTIONING.

Where two or more parts adjoin, the cross hatching is arranged to show the separate parts as in Fig. 15.



(a) Two adjoining parts. (b) Three adjoining parts.

FIG. 15. CROSS HATCHING OF ADJOINING PARTS SHOWN IN SECTION.

4.5 SCALES. It is frequently found that the drawing of an article is not to actual size but is a multiple or submultiple of true size. The scale used is stated on the drawing as a ratio for example 1:10. The first figure relates to the drawing and the second to the actual size of the article.

The statement 1:10 means that the drawing is one tenth of the actual size. Conversely, a ratio of 10:1 indicates that the drawing is ten times the size of the article.

5. MARKING OUT AND MEASURING

5.1 MARKING OUT or LINING OUT is the process of placing lines on the material being used to fabricate or modify a required article. Such lines indicate the exact position and nature of the operation specified in the drawing.

5.2 The principles employed in marking out are similar to those used in mechanical drawing. Marking out lines must be accurately located, as exact measurements are necessary and this means maintaining the measuring instruments and tools in good condition.

Before marking out a workpiece, an examination of the drawing should be made to decide what marking is necessary. The workpiece should be checked to ensure that sufficient material exists to allow finishing to the required size.

The marking out required and the tools used depends on the type of work, but all parts to be machined should be marked with lines for setting up and guide lines for machining. These lines can be made permanent by light punch marks, usually carried out with a prick punch. Sometimes work is partly marked and then partly machined before the marking is completed.

The job to be marked is usually coated with some type of marking medium which enables the lines to be distinctly seen. For small rough work, such as castings, chalk well rubbed in can be used, and for larger surfaces, white lead and turpentine or whiting mixed with water may be painted on.

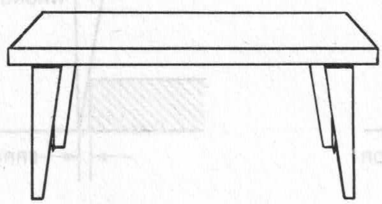
For finished or polished iron, and steel surfaces, a commercially prepared 'lay out' stain is available. A remover is used to remove the stain after use. Tool makers sometimes blue the steel by heating and the oxidised surface enables the finest lines to be clearly seen.

5.3 MARKING–OFF TABLES AND SURFACE PLATES. A basic essential for marking out a job is a suitable flat surface or table. This usually takes the form of a strong cast iron plate with an accurately machined flat surface. The edges are machined at right angles to this surface.

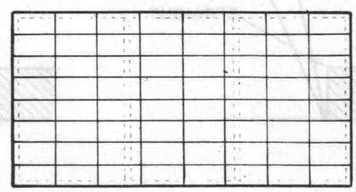
A large range of sizes are available, and they are either machined with sufficient accuracy for general marking out, or as in the case of the smaller surface plates, are made highly accurate for more specialised work. A marking off table mounted on stoutly constructed legs is shown in Fig. 16a. Others have three-point suspension; the table is supported on three adjustable screw pivots which allow it to be levelled up.

To assist in marking out, the table surface may be lined as shown in Fig. 16b. The lines are at right angles and evenly spaced at suitable intervals.

The marking-off table should have adequate lighting and be placed free of obstructions so that the users are free to walk around it and work from any angle.



(a) Typical Mounting



(b) Top of Table

FIG. 16. MARKING-OFF TABLE.

5.4 TYPES OF LINES. Lines inscribed on a job are broadly classified as foundation lines, data lines and dimension lines.

- A foundation line is one from which a number of dimensions are measured to avoid the cumulative error which may occur when measuring is done from line to line in succession. This line may be a machining line or it may be for measurement purposes only.
- Data lines are used to assist in establishing the position of dimension lines such as centre lines, from which circles or radii may be marked.
- Dimension lines indicate the size to which the work is to be finished, for example, a circle indicating the size and position of a hole.

5.5 SCRIBERS. Marking out lines must be sharp and clear and this requires the use of a sharp, hard pointed tool or scriber. A general purpose type of scriber in common use is shown in Fig. 17.

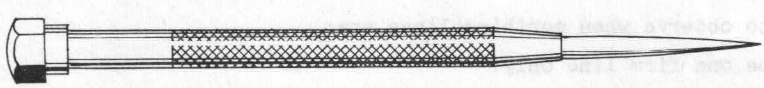


FIG. 17. GENERAL PURPOSE SCRIBER.

Scribers are made from hardened tool steel and some have tungsten carbide tips for long life. Pocket types have a reversible point held in position by means of a chuck. The tapered point of a scriber should have an included angle of 10-15^{o} and must be kept sharp. Fig. 18a shows a correctly ground scriber held at an angle least likely to produce errors.

Honing on an oil stone, should be carefully done to preserve the same taper of the point.

Honing is done by rotating the scriber between the thumb and fingers while at the same time stroking the point across the stone. Care should be taken to maintain the correct point angle when grinding and honing because there is a tendency to produce a rounded point. This must be avoided as a scriber ground in this way is likely to create errors when marking out. (Fig. 18b).

Fig. 18c shows how a correctly ground scriber can create an error when held at an incorrect angle.

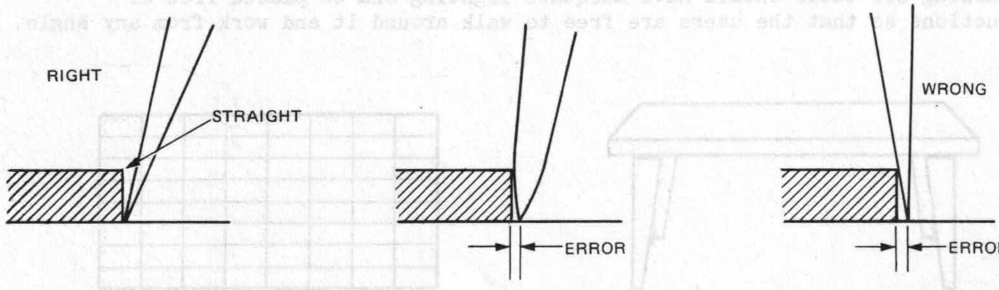


FIG. 18. USING THE SCRIBER.

When scribing lines, the scriber should be inclined in the direction of the stroke as shown in Fig. 19.

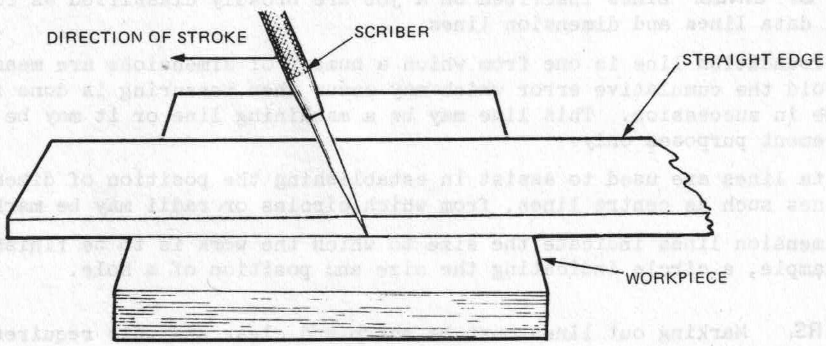


FIG. 19. SCRIBER INCLINED IN DIRECTION OF STROKE.

Other points to observe when scribing lines are:

- Scribe one firm line only.
- Use a marking medium such as Prussian blue, copper sulphate or whiting on the surfaces to be scribed to improve clarity.

5.6 STEEL RULE. The steel rule is used extensively when marking out. Rules are made of spring steel in various lengths, widths and graduations.

Steel rules are used for direct measurements on the work, and to establish measurements on dividers and calipers. As the steel rule is frequently used as a straight edge for testing flatness, etc., great care must be taken to prevent damage to its edges. Damage can occur if knocked against other hard tools such as files.

When using a steel rule for accurately measuring or marking out, it should be held on its edge as shown in Fig. 20.

The scriber point should be located in the required graduation mark and then moved down to contact the work.

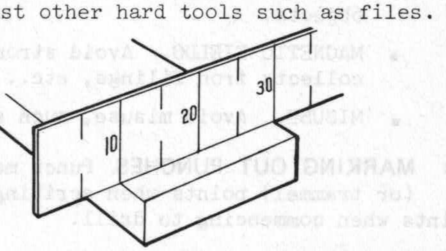
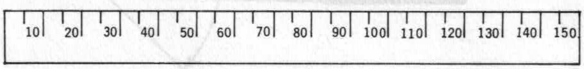


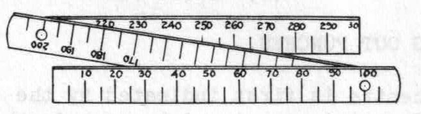
FIG. 20. POSITION OF RULE WHEN MEASURING.

Typical steel rules used for marking out include the straight type, the folding type and the hook rule. These are shown in Fig. 21. The folding steel rule has a number of short lengths hinged together to enable it to be folded for measuring or marking out in confined spaces. The hook rule is fitted with a short hook at one end to enable measurements to be obtained in otherwise inaccessible locations.

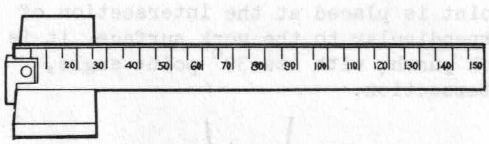
A flexible steel rule (Fig. 22) may be used for a variety of applications including measuring on curved surfaces. These rules are available in various lengths.



(a) Straight



(b) Folding



(c) Hook

FIG. 21. TYPICAL STEEL RULES.

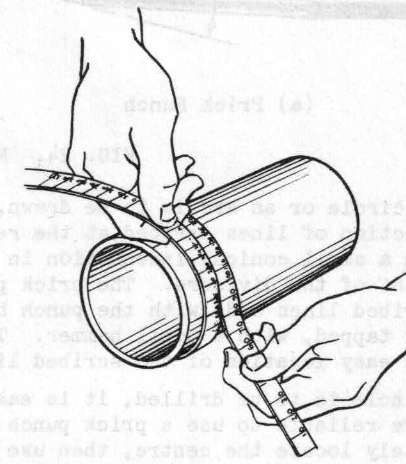


FIG. 22. MEASURING ROUND STOCK.

5.7 FLEXIBLE STEEL TAPE. The flexible steel tape is usually several times longer than steel rules and for this reason allows longer distances to be measured more quickly and with greater accuracy. Fig. 23 shows a typical steel tape retracted into its housing. When required the tape is simply drawn out to the desired length and in many cases it may be retracted by pressing a button on the housing. A hook is fitted on the end of the tape to enable a single handed operation when measuring from an edge.

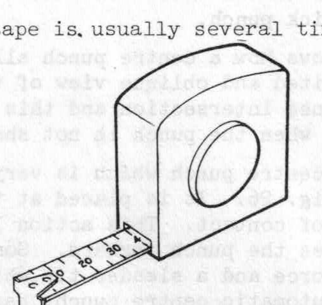


FIG. 23. RETRACTABLE STEEL TAPE.

5.8 CARE OF STEEL RULES AND TAPES. Maintaining steel rules and tapes in good condition involves such points as:

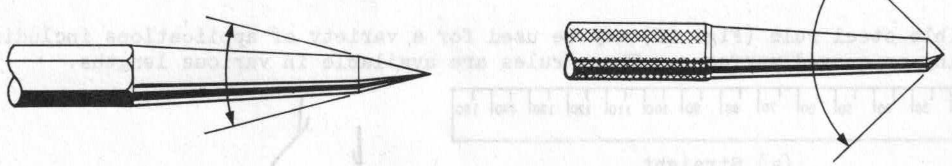
- CLEANLINESS. With some types, a little oil should be smeared on to prevent rusting.
- PROTECTION. Avoid mechanical damage caused by striking against hard objects.
- MAGNETIC FIELDS. Avoid strong magnetic fields as a magnetised rule collects iron filings, etc..
- MISUSE. Avoid misuse, such as measuring work which is in motion, etc..

5.9 MARKING OUT PUNCHES. Punch marks are mainly used either as pivots for divider (or trammel) points when scribing arcs and circles, or for locating drill points when commencing to drill.

Two types of marking out punch in general use are the:

- prick punch, with a point angle of 30°,
- centre punch, which is often heavier and has a 90° point angle.

These punches are shown in Fig. 24.



(a) Prick Punch (b) Centre Punch

FIG. 24. MARKING OUT PUNCHES.

When a circle or an arc is to be drawn, the centre is first indicated by the intersection of lines scribed at the required positions. A prick punch is then used to form a small conical indentation in the work surface. This serves as a pivot for the point of the dividers. The prick punch point is placed at the intersection of the scribed lines and, with the punch held perpendicular to the work surface, it is lightly tapped, with a small hammer. The prick punch, with its 30° point angle, permits easy location of the scribed lines intersection.

When a hole is to be drilled, it is easier and more reliable to use a prick punch to accurately locate the centre, then use a centre punch to deepen the impression. This is due to the better view obtained when using a prick punch.

Fig. 25 shows how a centre punch allows a very limited and oblique view of the scribed lines intersection and this effect is greater when the punch is not sharp.

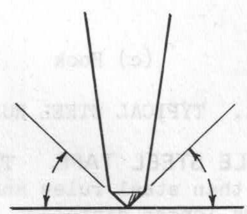


FIG. 25. LIMITED VIEW OFFERED BY CENTRE PUNCH.

A type of centre punch which is very convenient to use is the automatic centre punch shown in Fig. 26. It is placed at the required position and the body pressed towards the point of contact. This action loads and releases an internal striking mechanism which drives the punch forward. Some automatic centre punches have an adjustable striking force and a slender tip which may be ground for use as a prick punch. When using an automatic centre punch, care must be taken to ensure that the point does not shift when pressing the punch body forward.

When it is found that an indentation is not in the exact position required, the punch may be inclined to the work surface and struck with a hammer as shown in Fig. 27. A final blow should be delivered to the punch while held perpendicular to the work surface to 'true up' the indentation.

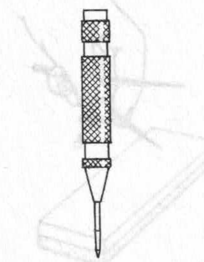


FIG. 26. AUTOMATIC CENTRE PUNCH.

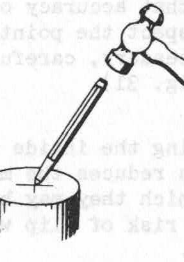


FIG. 27. MOVING OVER PUNCH MARK.

5.10 DIVIDERS. These are a two legged marking out tool used for setting out distances and scribing arcs or circles.

The spring type dividers (Fig. 28) consist of two pivoted legs, outwardly tensioned by means of a spring.

An adjustment screw and knurled nut serve to hold the legs at the required distance apart.

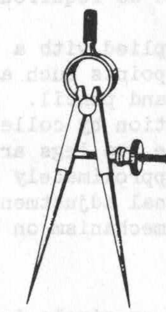


FIG. 28. SPRING TYPE DIVIDERS.

To set the dividers, hold as shown in Fig. 29, with one point in a suitable graduation on the steel rule. Adjust the knurled nut until the other point centres in the graduation which gives the required measurement.

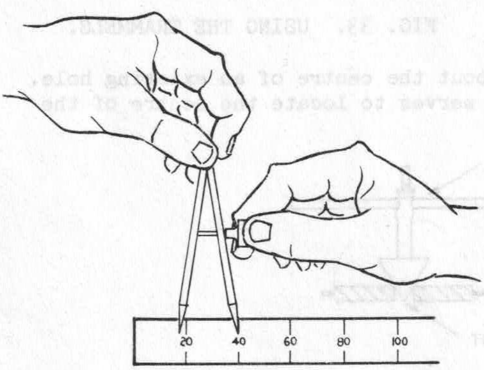


FIG. 29. SETTING DIVIDERS.

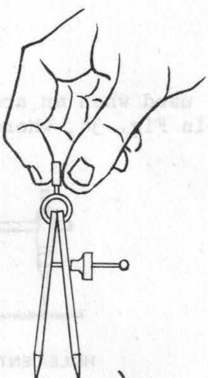


FIG. 30. USING DIVIDERS.

When scribing an arc or circle, locate one point in the lightly prick punched centre of the required circle and locate the knurled attachment between the thumb and forefinger as shown in Fig. 30.

Great care must be taken to ensure that the divider point at the centre of the arc, does not slip from its correct location. This is less likely to happen if the dividers are slightly inclined in the direction of rotation.

Divider points must be maintained in a sharp condition so that accuracy of marking out is achieved. Inspect the points before use and, where necessary, carefully sharpen on an oilstone. (Fig. 31).

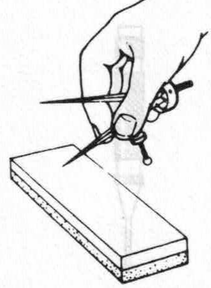


FIG. 31. SHARPENING POINTS ON OILSTONE.

Avoid sharpening the inside of the divider points as this reduces the minimum distance to which they may be set, and also increases the risk of slip when scribing large circles.

5.11 TRAMMELS. Large radius arcs or circles require the use of trammels. These are essentially a form of dividers and consist of a metal beam, upon which two legs can be positioned as required. (See Fig. 32).

The legs are supplied with a variety of interchangeable points such as scriber, vee points, caliper and pencil. These points are held in position by collets. To set the trammels, the two legs are positioned on the beam at approximately the distance required when final adjustment is made by varying a screw mechanism on one leg.

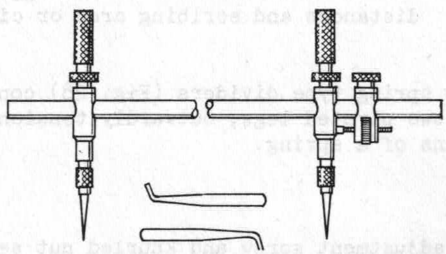


FIG. 32. TRAMMELS.

The required arc or circle is obtained by placing one point in the punch mark at the centre of the required circle and the other trammel point is used to describe the arc as shown in Fig. 33.

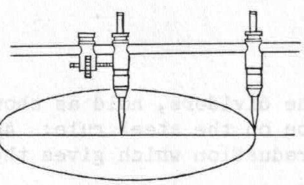


FIG. 33. USING THE TRAMMELS.

A Vee point is used when an arc is required about the centre of an existing hole. This is shown in Fig. 34, where the Vee point serves to locate the centre of the hole.

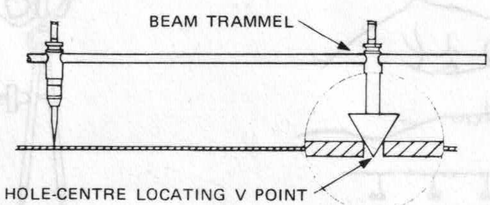


FIG. 34. USING THE TRAMMEL VEE POINT.

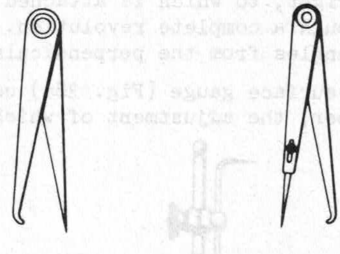
To ensure accuracy when using the Vee point, the hole must be quite free from burrs and the legs maintained perpendicular to the work surface.

5.12 HERMAPHRODITE CALIPERS OR JENNIES. Sometimes known as 'odd-legs', these calipers have one divider type leg and one caliper leg.

The divider leg may be fixed or adjustable as shown in Fig. 35.

They have many uses in marking out, including finding the centre of round stock, constructing lines parallel to edges or shoulders, and transferring distances.

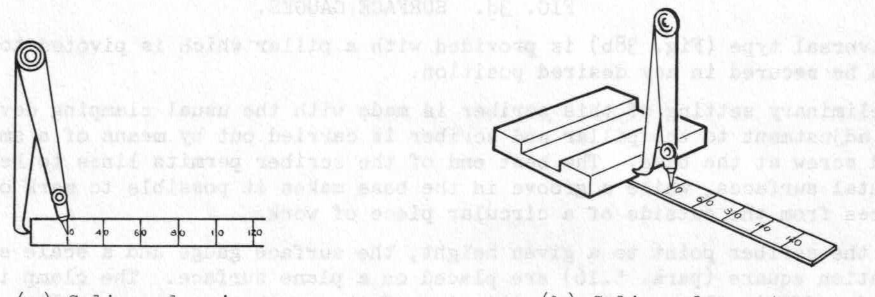
The fixed leg type has a limited life as repeated resharpening renders the divider leg shorter than the other. The adjustable type has a scriber which can be set to the correct length or replaced as required.



(a) Fixed Leg. (b) Adjustable Leg.

FIG. 35. HERMAPHRODITE CALIPERS OR JENNIES.

The hermaphrodite calipers may be used to scribe lines parallel to either outside or inside edges. This simply requires that the relative positions of the legs be reversed and set to the required dimensions as shown in Fig. 36a and b.



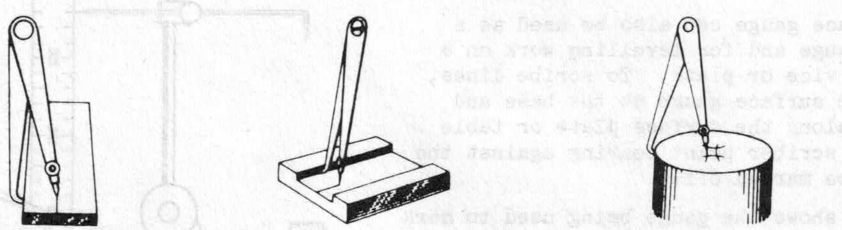
(a) Caliper leg in. (b) Caliper leg out.

FIG. 36. SETTING THE CALIPERS.

To scribe a line parallel to an outside edge, set the caliper leg against the edge and scribe a line as in Fig. 37a. Ensure that the caliper points are maintained at right angles to the line being scribed.

To mark off a line parallel to an internal edge, set the calipers and use as in Fig. 37b.

To find the centre of circular stock, set the calipers at the approximate radius, and scribe lines with the caliper leg placed in four different positions round the periphery. The centre is then in the middle of the small area enclosed as shown in Fig. 37c.

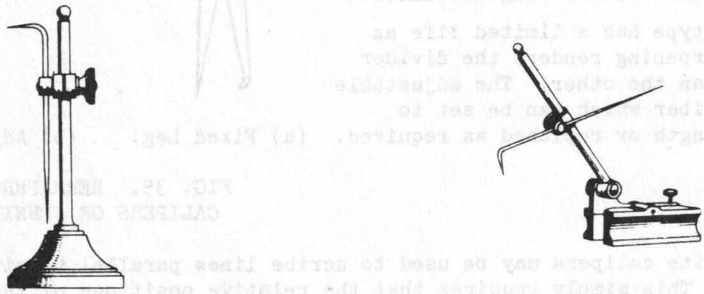


(a) Scribing a line parallel to an edge. (b) Line parallel to an internal edge. (c) Finding the centre of round stock.

FIG. 37. USING THE CALIPERS.

5.13 SURFACE GAUGE. The surface gauge is an instrument used for scribing lines at a given height from some face of the work, or for the construction of lines around several surfaces of a job. The gauge consists of a heavy base and a spindle pivoted upright, to which is attached a scriber held by a clamp. The scriber may be turned through a complete revolution. In some types the pillar can also be set at different angles from the perpendicular.

The common surface gauge (Fig. 38a) consists of a pillar rigidly fixed into a base, and a scriber, the adjustment of which is made with the clamping device shown.



(a) Common Type (b) Universal Type

FIG. 38. SURFACE GAUGES.

The universal type (Fig. 38b) is provided with a pillar which is pivoted to the base and can be secured in any desired position.

The preliminary setting of this scriber is made with the usual clamping device while a fine adjustment to the pillar and scriber is carried out by means of a small knurled screw at the base. The bent end of the scriber permits lines to be drawn on horizontal surfaces, while a groove in the base makes it possible to mark out desired distances from the outside of a circular piece of work.

To set the scriber point to a given height, the surface gauge and a scale such as a combination square (para. 5.16) are placed on a plane surface. The clamp is then loosened sufficiently to allow positioning of the scriber as shown in Fig. 39.

Note that there is less chance of inaccuracies due to movement of the scriber when it is clamped as near parallel to the base as possible and with the scriber point to be used as near to the pillar as is practicable.

By resting both the surface gauge and the work on a plane surface, lines may be drawn at this height on all faces of the work, or on any number of pieces when duplicate parts are being made. The use of the gauge is not confined to the scribing of horizontal lines, but may also be used on other surfaces from which it can be conveniently guided or held.

The surface gauge can also be used as a height gauge and for levelling work on a machine, vice or plate. To scribe lines, grasp the surface gauge at the base and move it along the surface plate or table with the scriber point bearing against the work to be marked off.

Fig. 40, shows the gauge being used to mark out a piece of round work placed in a Vee block (para. 5.14) and Fig. 41 shows its use in scribing parallel lines on a horizontal surface.

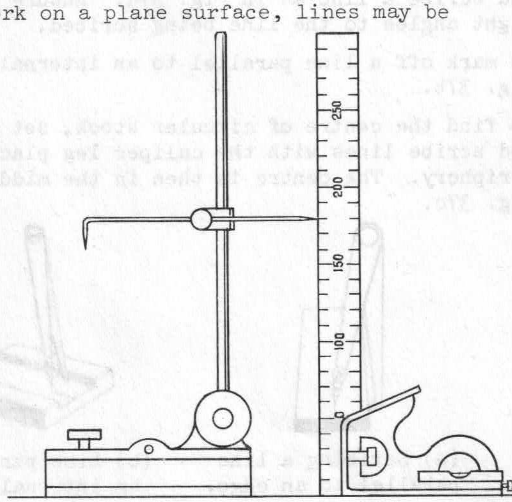


FIG. 39. SETTING THE SURFACE GAUGE.

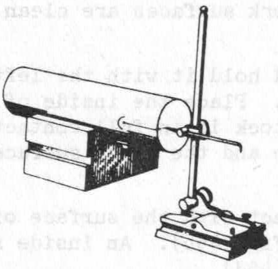


FIG. 40. USING SURFACE GAUGE ON ROUND WORK.

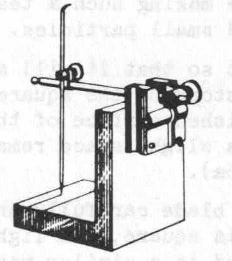


FIG. 41. USING SURFACE GAUGE ON HORIZONTAL SURFACE.

All rough projections etc., should be removed from surfaces upon which lines are to be drawn as well as those upon which the work rests.

Ensure that the base of the surface gauge, the plate or table on which it rests, and the work are clean, then decide on the best position in which to set the spindle and scriber on the gauge.

5.14 VEE BLOCKS. These blocks (Fig. 42) are used for holding round section stock when marking out and performing some types of machining such as drilling.

In the example shown, two opposite faces are machined out to form a 90° 'V' and the adjacent sides are slotted to carry the yoke of a clamp used to secure the work piece in the 'V'.

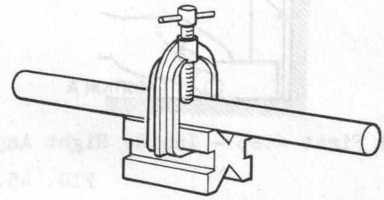


FIG. 42. VEE BLOCK.

5.15 STEEL SQUARE. A square is used for marking out and testing the accuracy of surfaces which have to be at a certain known angle to each other (usually 90°), and different types are made to suit varying requirements.

The common Try square is shown in Fig. 43. The blade is fitted into a slot provided in the stock, and both are rivetted together at 90°. The stock is made of larger section than the blade, and being heavier, allows the square to be used on the marking-off table, etc., without falling over.

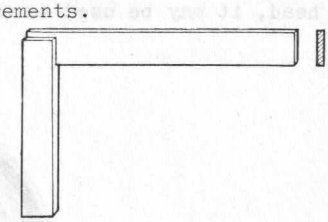


FIG. 43. TRY SQUARE.

To test for accuracy the try square is held with the stock against the edge of the surface plate and a light mark is scribed along the edge of the blade. This is shown in Fig. 44, position A. The square is then reversed to position B; the blade should then coincide with the previously drawn line.

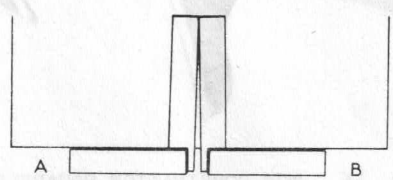
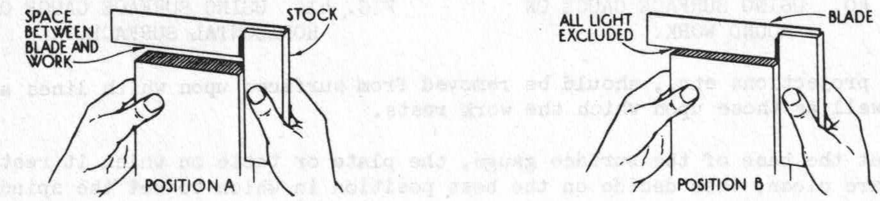


FIG. 44. TESTING THE SQUARE.

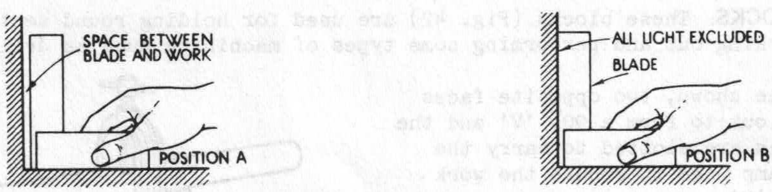
The try square is used to test two faces intended to be at right angles to each other. Before making such a test, ensure that the work surfaces are clean, free from burrs and small particles.

Face the light so that it will shine on the work, and hold it with the left hand, grasping the stock of the square with the right hand. Place the inside of the square against a finished surface of the work so that the stock is in full contact with that surface, and a slight space remains between the blade and the other surface of the job. (Fig. 45a).

Now lower the blade carefully until it comes in contact with the surface of the work. If the angle is square, all light will be excluded (Fig. 45b). An inside right angle is tested in a similar manner. (Figs. 45c and 45d).



(a) First step - Outside Right Angle (b) Second step - Outside Right Angle



(c) First step - Inside Right Angle (d) Second step - Inside Right Angle

FIG. 45. USING THE SQUARE.

5.16 COMBINATION SQUARE (FIG. 46). This is widely used for lay-out work. The stock or head can be moved along the steel blade and clamped in any desired position. It can be used as a square to check angles of 45^{o} and 90^{o}, as a depth gauge, and also for marking off lines. By setting the end of the steel rule flush with the head, it may be used as a height gauge.

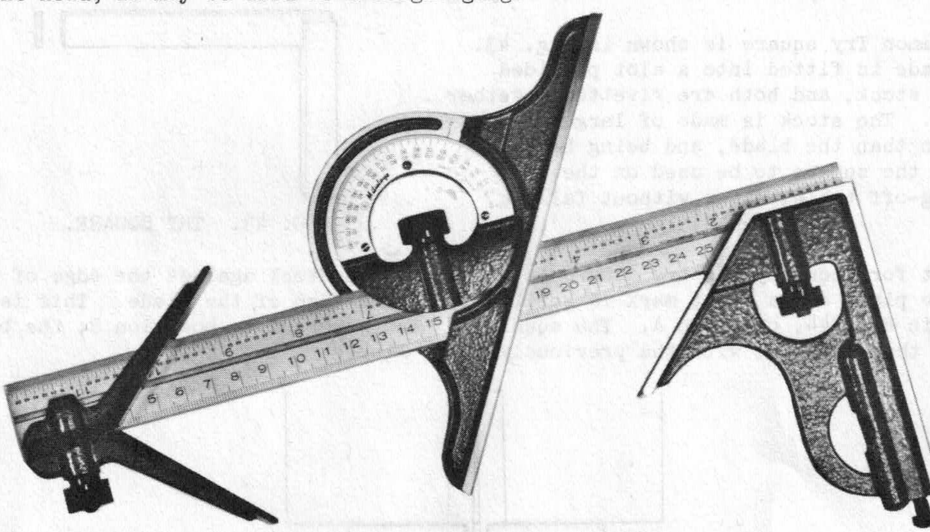


FIG. 46. THE COMBINATION SQUARE SET.

Combination square sets, in addition to a square head, include a protractor head and a centring head. The two most frequently used angles, 45° and 90°, are measured or laid out with the square head. Any angle can be set with the protractor head. Both square and protractor heads are usually fitted with spirit (non-freezing) level bubbles. The heads have clamps that grip the blade so that they may be positioned anywhere along it.

To locate the centre of round stock, place the centring head in the position shown in Fig. 47 and scribe a line across the centre of the work. Turn the head through about 90° and scribe a second line. The intersection of the two crossed lines occurs at the centre of the work piece.

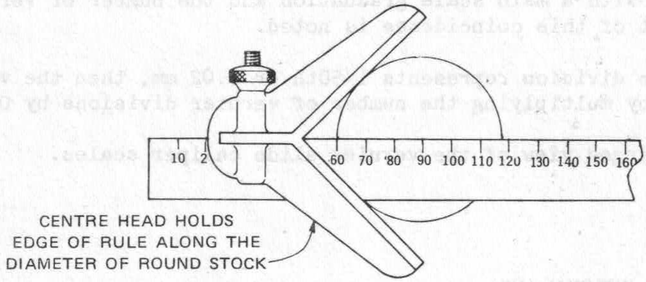


FIG. 47. USING A CENTRING HEAD.

Combination square sets require little maintenance other than to be kept clean and have a little oil placed on the sliding surfaces occasionally. They should be protected against knocks from hard objects and carefully stored away when not in use.

5.17 VERNIER SLIDE CALIPER. When measurements require a greater order of accuracy than that attainable with the simple steel rule, other measuring instruments, such as the vernier slide caliper and the micrometer, are used.

The vernier slide caliper shown in Fig. 48, is designed to allow internal and external measurements to within 0.02 mm to be made.

This instrument employs the basic concept of a main scale attached to the fixed jaw and an auxiliary scale on the sliding jaw.

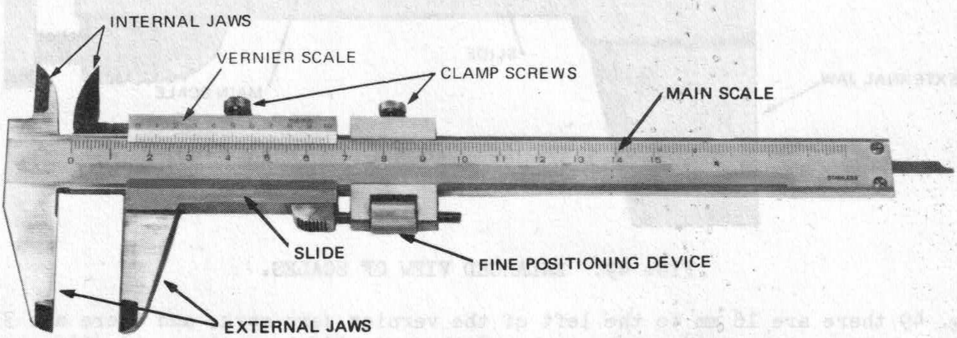


FIG. 48. THE VERNIER SLIDE CALIPER.

The upper jaws are used for making internal measurements and external measurements are made with the lower jaws. A metal tongue used for depth measurements can be seen protruding from the right hand end of the main scale. This tongue is attached to the sliding jaw and protrudes by a distance equal to the jaws opening.

The main scale is graduated in millimetres and tens of millimetres for most of its usable length and when the caliper jaws are closed, the zero mark of the vernier scale coincides with the zero mark on the main scale.

The vernier scale has 50 divisions, each representing 1/50th or 0.02 mm.

To read the slide caliper, the number of whole millimetres to the left of the vernier scale zero is read and added to the vernier reading.

To obtain the vernier reading, careful examination is made to see which vernier graduation coincides with a main scale graduation and the number of vernier divisions to the left of this coincidence is noted.

As each vernier scale division represents 1/50th or 0.02 mm, then the vernier reading is obtained by multiplying the number of vernier divisions by 0.02.

Fig. 49 shows an enlarged view of the vernier slide caliper scales.

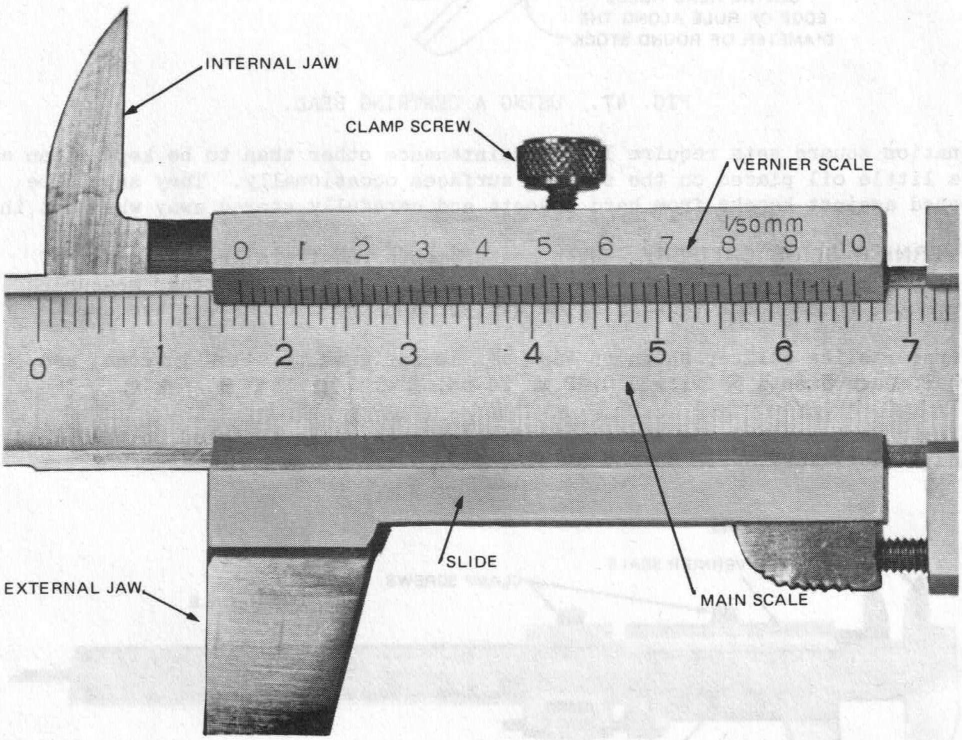


FIG. 49. ENLARGED VIEW OF SCALES.

In Fig. 49 there are 16 mm to the left of the vernier zero mark, and there are 31 divisions between the vernier zero mark and the coincident vernier graduation mark. This means that 31 × 0.02 or 0.62 mm must be added to the main scale reading of 16 mm. The jaws opening is then 16 + 0.62 or 16.62 mm.

When difficulty is experienced in accurately determining the vernier scale reading, a suitable magnifying glass should be used.

5.18 MICROMETER. In its basic form it is used to accurately measure diameters and thicknesses to within 0.02 mm. This degree of accuracy is increased to 0.002 mm by the addition of a vernier scale.

Variations of the basic micrometer are used to make internal and depth measurements.

An 0-25 mm outside micrometer is shown in Fig. 50.

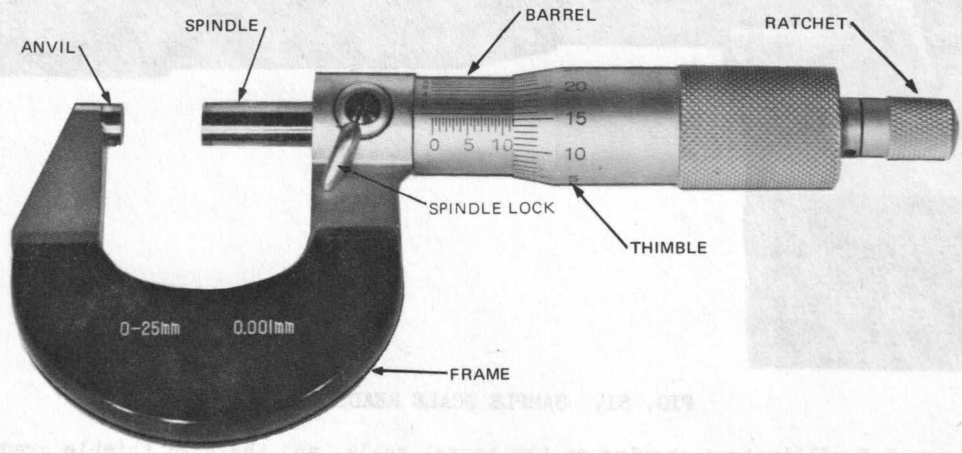


FIG. 50. OUTSIDE MICROMETER.

The outside micrometer has a C shaped frame, one end of which carries the anvil or fixed jaw, and the other end is internally threaded to take the movable jaw or spindle.

A spindle locking device is often provided to clamp the spindle at a given dimension. This feature enable measurements to be made in unfavourable light or otherwise inconvenient positions. The micrometer can be locked and removed to a more suitable position for reading.

The indicating system comprises two parts. These are:

- The barrel which is fixed to the frame and is calibrated longitudinally in millimetres and half millimetres.
- The thimble which is mounted on the spindle and is divided circumferentially to indicate fractions of a revolution.

As the spindle has 2 threads per millimetre, one full turn of the spindle moves the contact face of the spindle towards or away from the anvil face by 0.5 mm.

The thimble scale has 50 divisions, therefore each division represents 1/50th of 0.5 mm or one hundredth of one millimetre (0.01 mm).

The index for the barrel scale is the bevelled edge of the thimble, and the index for the thimble is the longitudinal line on the barrel. When the micrometer jaws are closed, the scale zero on the thimble coincides with the longitudinal index line on the barrel and the barrel zero coincides with the bevelled edge of the thimble.

Now consider the scale readings shown in Fig. 51.

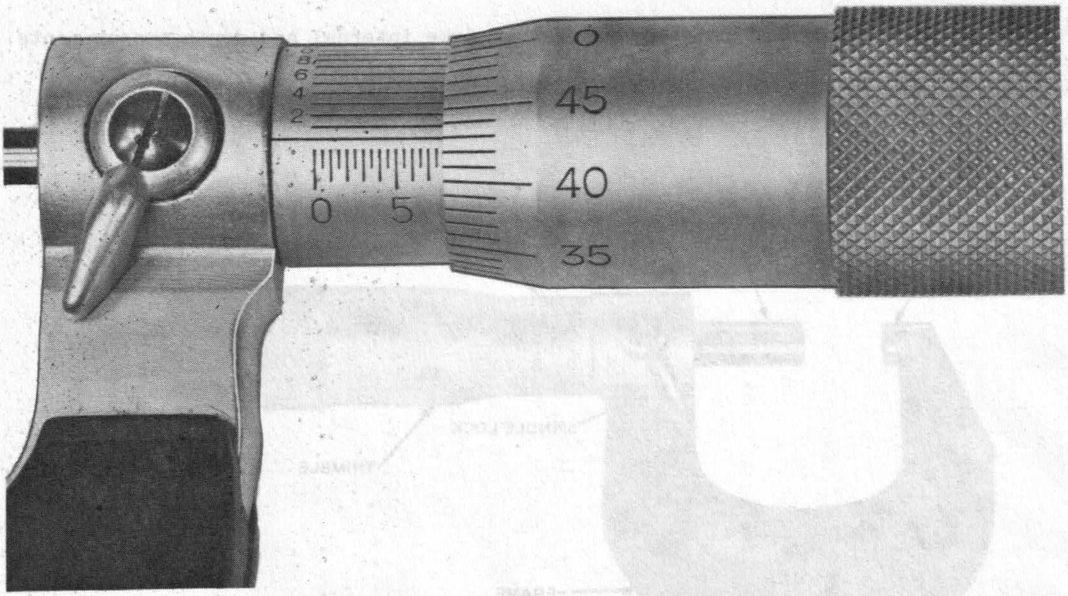


FIG. 51. SAMPLE SCALE READING.

There are 7.5 millimetres showing on the barrel scale, and the 43rd thimble graduation mark almost coincides with the index line on the barrel. This means that 43 hundredths of one millimetre (0.43 mm) must be added to the number of millimetres indicated on the barrel. The micrometer reading is, therefore, 7.5 + 0.43 or 7.93 mm. This reading is accurate to the nearest one hundredth (0.01) of a millimetre.

The micrometer shown in Fig. 51, has a vernier scale which increases the accuracy of the basic instrument tenfold. Readings can be made to within one thousandth of a millimetre (0.001 mm) when the vernier facility is used.

Fig. 51 shows that ten additional numbered lines (2,4,6,8,0) are engraved parallel to the barrel scale, each line representing one thousandth of a millimetre (0.001 mm).

Assume that in Fig. 51, the 9th vernier scale line coincides with a thimble graduation. This means that the true reading is not exactly 7.93 mm but 7.92 + (9 × 0.001) which equals 7.929 mm.

Note that when the longitudinal barrel index line lies between two thimble graduations, the lower of the two must be used to indicate the number of one hundredths of a millimetre. The vernier scale then indicates the remainder in one thousandths of a millimetre. Referring back to Fig. 51, note that the barrel index line is slightly under 43, that is 0.43 mm. Therefore, the vernier scale reading is added to 42 (0.42 mm).

5.19 USING THE MICROMETER. The method of holding the micrometer depends largely on whether the material to be measured is held in the hand or is mounted in a fixture. When the piece to be measured can be conveniently held in one hand, the micrometer is best held with the little finger of the right hand crooked through the frame and the thimble gripped between the thumb and forefinger. The remaining two fingers are conveniently placed to support the frame of the micrometer as shown in Fig. 52.

Before making a measurement with the micrometer, first ensure that the faces of the anvil and spindle are clean. Then rotate the thimble until the surfaces meet lightly. Check that the thimble scale zero exactly coincides with its index line on the barrel. Too little torque produces a reading above zero and too much drives the thimble below zero. This test should be practised until a feel for the correct torque is developed. This same pressure must be used when measuring an item so that the correct reading is obtained.

FIG. 52. SUITABLE MICROMETER GRIP FOR MEASURING HAND HELD ITEMS.

High quality micrometers have a ratchet device (Fig. 50) which allows only a predetermined maximum torque to be exerted on the thimble. When this torque is exceeded the ratchet device slips. To measure an object, rotate the thimble to separate the measuring surfaces and place the object between them. Rotate the spindle until correct pressure on the work piece is achieved and then carefully take the reading.

When the object to be measured is fixed in position, both hands may be used. The left hand is used to support the micrometer while the thimble is adjusted with the right thumb and forefinger.

5.20 CARE OF SLIDE CALIPERS AND MICROMETER. These instruments must be kept clean and dry when not in use. A little light machine oil should occasionally be applied to the vernier slide caliper sliding surfaces and the sliding jaw moved from end to end a few times to ensure penetration. The micrometer spindle thread also requires a drop of light machine oil. To do this the spindle is removed by unscrewing from the frame.

Never allow these instruments to be knocked or have other tools, etc., placed on them. Protect them from flying particles of hot or molten metal.

ENGINEERING WORKSHOP—METALS, MARKING OUT AND MEASUREMENTS

6. TEST QUESTIONS

1. *Briefly outline safety features regarding clothing and personal appearance required in the workshop situation.*

2. *Explain the term ductility and give an instance where this property is made use of in the manufacture of telecommunications equipment.*

3. *Describe a simple test which can be used to identify types of steel.*

4. *What component metals are alloyed to form bronze?*

5. *What is meant by the term 'sectioning' as applied to engineering drawings?*

6. *List three materials which may be used to coat a workpiece, prior to marking out, so that the lines may be clearly seen.*

7. *Describe the correct method, using a steel rule and scriber, to transfer measurements onto a workpiece.*

8. *Why is a prick punch used prior to centre punching when marking out a workpiece.*

9. *What instrument is used to describe a large arc about the centre of an existing hole?*

10. *Describe a simple method of testing the accuracy of a try square.*

11. *Show by means of a sketch how the centre of a piece of round stock may be accurately located.*

12. *Name two instruments which may be used to accurately determine the diameter of a twist drill.*

13. *List the advantages each one of the instruments in Question 12 has over the other.*

14. *What order of accuracy can be obtained by using the more accurate of the two instruments in Question 12.*

END OF PAPER.